

Pattern Formation and Group Size Regulation In Swarm Robotics

R. O'Grady

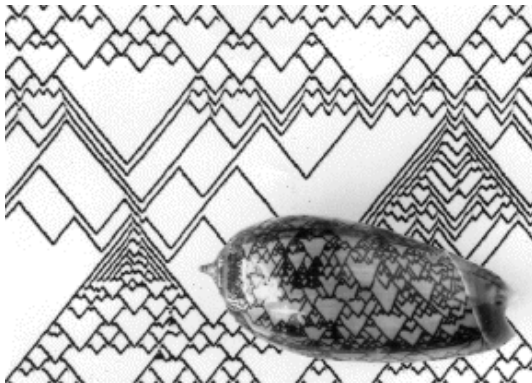
IRIDIA, Université Libre de Bruxelles, Brussels, Belgium

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Examples of Self Organising Patterns



Artificially constructed self organising patterns



It's pretty, but what's the point?

Functional Pattern Formation



Some Distinctions

- Connected Pattern vs. Unconnected Formation
- Local vs. Global Pattern Definition
- Global Pattern Definition vs. Centralised Control

Literature - Cellular Robotic Systems

Simulated Grid Based System



J. Wang, G. Beni

Cellular Robotic Systems: Self-Organizing Robots and Kinetic Pattern Generation



Fig.5 An alternating pattern of 2 types of robots

snap shot	configuration	rules being followed				
		a	b	c	d	e
1		1	3	4	5	5
2		-	5	2	3	4
3		-	-	-	5	2
4		-	-	-	-	-

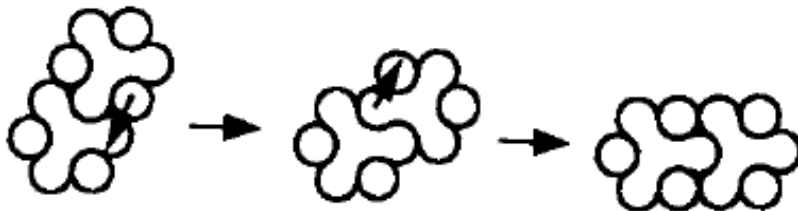
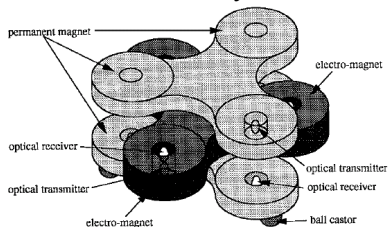
Fig.6 Generating an alternating pattern

- (1) If I am at the leftend, terminate immediately.
- (2) If l , the robot to my left, has terminated and $mytype \neq type(l)$, then terminate.
- (3) Let l and r denote the robots to my left and right, respectively. If $mytype = type(l)$ and $mytype \neq type(r)$, then "ask" r to swap site with me. Do not start to move towards the site to the right (i.e., wait) until it becomes empty.
- (4) If I am "being asked" to make a swap with the robot to my left, start to move towards the site immediately. Do not enter the destination site (i.e., wait) until it becomes empty.
- (5) Do nothing if none of the above happens.

Literature - Self Assembling Patterns



K. Tomita, S. Murata, H. Kurokawa, E. Yoshida, S. Kokaji
Self-Assembly and Self-Repair Method for a Distributed
Mechanical System

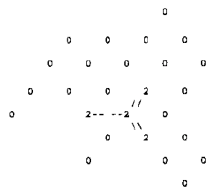
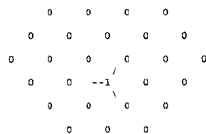
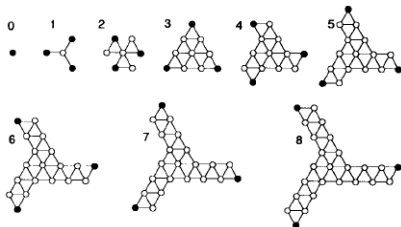


Literature - Self Assembling Patterns

Self-Assembly and Self-Repair Method for a Distributed Mechanical System

	location index (l)								
	0	1	2	3	4	5	6	7	8
stage (s)	0	n							
1	Y	e							
2	s	o	o						
3	-	K	K	o					
4	-	-	f	ε	o				
5	-	-	-	K	ε	o			
6	-	-	-	-	K	ε	o		
7	-	-	-	-	-	K	ε	o	
8	-	-	-	-	-	-	K	ε	o

T



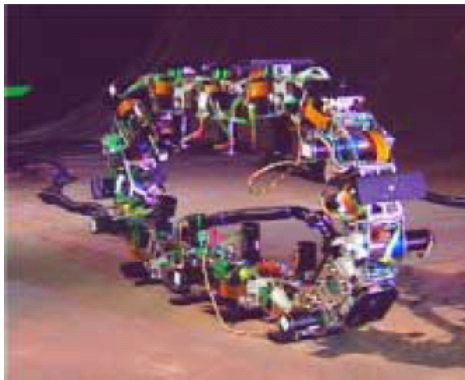
Literature - Configurable Modular Robotics

Polybot



M. Yim, K. Roufas, D. Duff, Y. Zhang, S. Homans

Modular Reconfigurable Robots in Space Applications



Literature - Group Size Selection

Choruses and Convoys



C. Melhuish, O. Holland, S. Hoddell

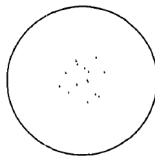
Convoying: using chorusing to form travelling groups of minimal agents

Chorus

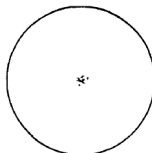
- 1 Chirp
- 2 Pause
- 3 Chirp with probability or if hear chirp

Group size \propto

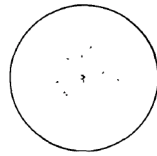
- number of stimulated chirps between unstimulated chirps.



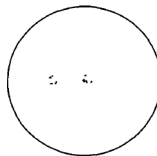
(a)



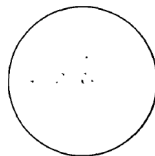
(b)



(c)



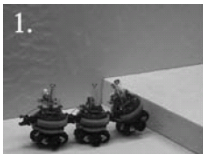
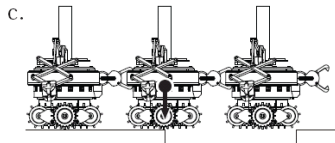
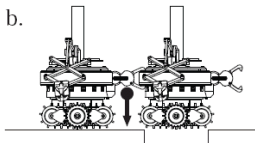
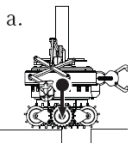
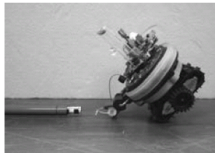
(d)



(e)

Effect of groupsize on efficiency

Super Linear Performance



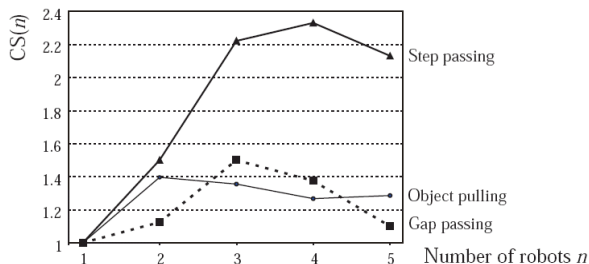
Super Linear Performance



F. Mondada, M. Bonani, A. Guignard, S. Magnenat, C. Studer, D. Floreano

Superlinear Physical Performance in a SWARM-BOT

$$CS(n) = \frac{mP(n)}{nP(m)}$$



Extensions: Pattern based. Autonomous.

Functional pattern formation

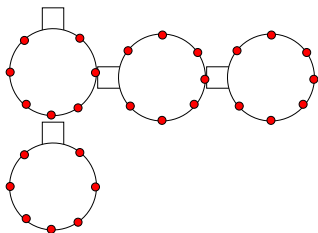
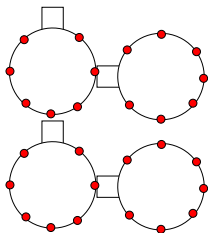
Pattern specific effects on efficiency

- Stability
- Interference
- Access - Gripping an object
- Dimensions - Narrow gaps

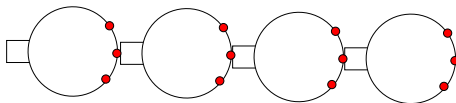
Pattern formation using the sbots

So far, camera based only. Ideas welcome!!

Traditional Self Assembly. All LEDs Illuminated - No pattern constraints.



INSTEAD: Create pattern by illuminating selected LEDs



Links to other work in IRIDIA

- Shervin - Chain is sort of pattern / formation already
- Anders - Fault detection will sometimes imply swarm reformation - new pattern.
- Rodi - More / less efficient swarm configurations for transport.
- ???

What's my problem?

- Hill Climbing
- Hole Crossing
- ...
- ???